A New larger-scale Collaboration Architecture

Wu Wenjun, Lu jian, Jin tian, Sheng Xiangzhi Li Wei
National Lab of Software Development Environment,
University of Aeronautics and Astronautics
{wwj,lujian,jintian,xzsheng,liwei}@nlsde.buaa.edu.cn

Abstraction

We propose a hierarchy collaborative environment structure, in which layered transmission technique combined with source-specific multicast is applied and floor control mechanism is considered. Therefore network bandwidth and computing resource consumed in a collaboration session can be optimized, and the scalability of architecture can be archived.

Keywords collaboration, hierarchical conferencing, layered transmission, source-specific multicast, floor-control

1. Introduction

Because of the limitation of network bandwidth and computing ability of terminal nodes, the number of nodes in current Internet multimedia collaborative environment does not exceed a hundred. And the scope of collaboration is mainly restricted to Intranet or nation-wide Internet. Access Grid is preparing SC01 Global, which requires a larger collaborative environment. How to build an environment, which supports real-time video, audio and application sharing among more than 1000 nodes across the global Internet? We propose a hierarchy structure to replace the flat structure of the current Internet conferencing system, and use layered video transmission technique so that the bandwidth usage and computing resource consumed in a collaboration session could be reduced.

The paper is structured as follows. In section 2, we discuss method and structure to achieve that goal. And in section 3, we compare it to the current structure of videoconference. In the last section, we draw some conclusions.

2. Hierarchical Architecture of Collaboration Environment

2.1. Hierarchical collaboration environment

We suggest construct a two-layer collaborative working environment. There are two types of sites in the whole system: global sites and local sites. The global sites constitute main collaboration scenario, which can send audio and video to all sites in the system. High quality video stream can be transmitted between the global sites. The local sites in same area can be aggregated into a local scenario. The video and audio streams from them can only be shared in the local system group. Every sub-meeting group has a designate node in the main meeting sites to relay audio and video streams from it. The sketch map of architecture is below:
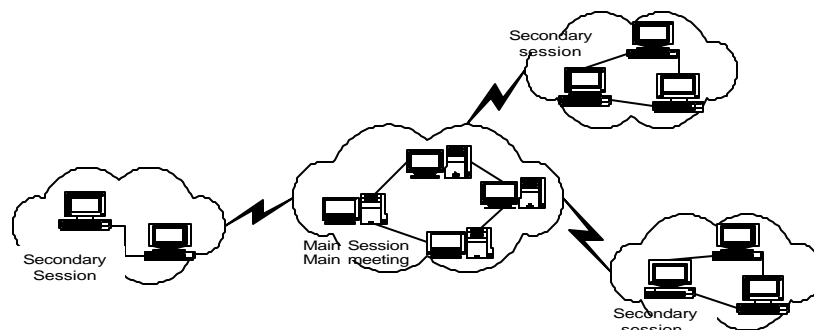
The designate site of sub-meeting group could perform many functions. It can combine audio or video from sub-meeting sites together to make up a sense in the mass. It can also

move a site in sub-meeting sites automatically to the main meeting sites by switching audio and video streams according to the focus of the scenario. It can also make a direct channel between sites in sub-meeting sites and the main meeting sites by request of any site in main meeting sites, helping sites to get a clearer awareness of sub-meeting sites.

Using the technique of virtual video, the designate site could combine lots of video stream from different site together to build a virtual meeting room. By this way, the video from every sub-meeting site could be placed into virtual sense, making it more natural for people at main and sub-meeting sites to communicate with each other

Electronic whiteboard and playing back of 2D image is an indispensable facility in cooperative environment. In the architecture mentioned above, the whiteboard can also be divided to two types: top-board and sub-board. The top-board is for interaction between global sites, while the sub-board is for interaction in sub-meeting sites. The designate site will export some content of sub-board to top-board, and send all the content of top-board to sub-board. Normally, the sub-board should be displayed in top-board as an abbreviation graph. Everyone can choose his/her interested pages in sub-board and view the detail. For playing back 2D image, maybe we should limit that only global site could publish its image. The designate site should take responsibility of perform transmitting these large-scale images reliably in real-time manner.

This hierarchy architecture will solve the limitation on the scale of collaboration imposed by current computing and communicating infrastructure and help to create a good pattern for large-scale collaboration. It can be assumed that, in the interactive meeting including thousands of people, every participant would only focus their attention on the sites nearby or correlating closely to current conferencing topic. This layered architecture is similar to the pattern of interaction between presidium and audiences in the real world.

The designate site of sub-meeting sites could reduce the amount of multimedia data to be transmitted real-time in collaborative environment and save bandwidth by combining and filtering audio and video data from sub-meeting sites.

The current electronic whiteboard tools can only perform interaction among no more than one hundred participants. The scalability of centralized whiteboard based on server/client model is limited by the processor power of the server. In the case with too many participants, the response time of server will go up because of the heavy workload. The multicast enabled whiteboard uses a reliable multicast protocol like SRM [2]. But the amount of session control message of these protocols will increases quickly along with the increase in site numbers. At the same time, the packets multicast for error correction will increase rapidly either. These increases cost network and site resource greatly. There are some researches on layered or local-repairing SRM techniques. But these techniques have not been widely used in whiteboard. A layered collaborative environment will provide a platform to implement large-scale whiteboard.

The publishing and playing back 2D image real-time needs to transmit lots of data reliably. It is suggested that such application should adopt a layered reliable multicast protocol, like RMTP[8]. In the layered cooperative environment, the sub-meeting sites could be regard as a node or a sub-tree of RMTP. The designate site can take the responsibility of DR in RMTP to transmit image data reliably.

2.2. Layered Video Transmission combined with SSM

Video data consume most resources in collaborative environment. And because the current multicast model, a end-user is likely to be overflowed when joining a very large-scale

collaboration session. Layered video transmission combined with Source-specific multicast seems to be a promising solution to avoid this danger, reduce video resource usage, and be adaptive to heterogeneous network environments. The video will use a layered-coding scheme [5,6], which sends different layer's data (include a basic layer and some enhanced layers) in different multicast groups. The receiver could receive one or many layers, according to its network capability. If the receiver gets more layers, he will get more video data, and get better quality video, and vice versa.

In heterogeneous Internet, each receiver will select different video sources according to the video's importance and network status, which optimize the network usage. For example, by contrast with others, the speaker is the most important in collaboration. If a receiver's network bandwidth is low, he can use SSM to choose sources according to its interests, and get more video layers for speaker, and few video layers for others.

Layer adjustment is divided into two parts, manual adjustment and self-adaptive adjustment. A receiver could use high quality to receive some important people's video, and use low quality to receive other participants' video. The video transmission protocol will dynamically adjust video layers based on receiver's strategy and network status. The principle in our layered collaborative environment is: global nodes should use layered encoding scheme, and other participant select proper layers and sources according to their network bandwidth and interests. Global nodes always request high quality video from all nodes, whereas local nodes only request best quality video he can afford from global nodes.

2.3. The Floor-Control in the Hierarchical Collaboration Environment

Floor-control is a mechanism used to solve the resource conflicting problem between different users and help coordinate and synchronize them in the collaboration work.

2.3.1 Resources that requires floor control

(1) Video channel and audio channel.

As the two channels always appear synchronously, their floor-control can also be accomplished at the same time. For example, if someone at local sites wants to say something or ask a question, he must get the right of speaking at first and then his video and sound data can be switched to the global sites.

(2) Whiteboard and other shared application:

- Authoring PowerPoint, Flash, Word
- Shared Large Static Picture, PS Files and etc

In both of the application, users can't be granted the floor freely. They can only be given by the administrator of the whole session.

- Short words, drawing

Any user can have the right of drawing, but the number of people who is able to write must be restricted according floor-control policy. Floor-control can also be specially associated with the whiteboard, which can limit the right of writing in some important pages.

2.3.2 The Floor-Control Scheme in Hierarchical Collaboration Work Environment

We can use centralized control policy to implement floor-control. There are major control nodes in both central and sub-meeting sites, which control the floor respectively. Every meeting site can decide its own floor-control policy.

1) Audio and video control

Inside the main and sub-meeting sites, we believe that the socialized coordination or the president-based control policy will be easier to implement comparing with other control methods and they won't lead to the increase of the communication delay. Further-more

socialized coordination suits well in the science discussion. It can also improve the cooperation atmosphere.

To transmit the video and audio flow from the local sites to the global collaboration environment, we need to use the explicit floor-control and consider two instances.

If there is no local speaker, we can shut down the audio of local sites and switch among the video from local sites. (Of course, we can also use video composing mechanism.)

If there is a local speaker, i.e. there is a sender applying for the right of speaking in a chairman mode session, his video and audio channels can be switched to global scenario after approval. A local session chairman can report the local application to the top-chairman or switch directly. If there are several requests, a sub-chairman can make a choice manually or by round robin or stochastic methods.

2) Whiteboard and other shared application's control

- Authoring:

  This kind of communicating mode is used in showing two-dimension picture files. After setting a display sever, two-dimension picture files can be uploaded to this sever. According to the script appointed by the top-chair and the progress of the session, we can real-timely multicast the data file to be displayed. A session joiner can upload display files which will be multicast by this sever after the admission of the session's chairman.

- Big picture:

  A joiner can only add this kind of object to the top-board or sub-board after the permission of top-chair or sub-chair. This policy can limit the number of users who can send massive data in order to control the usage of network bandwidth by whiteboard application.

- Short Words, Drawing

  we can give users different access permission according to the Top-Board/Sub-Board structure. For example, a global node have the right of writing? moving and deleting on the Top-Board, but it can only read on a Sub-Board page. And similarly, a local node has all the operating right on local site's sub-board and it can only read on other's sub-board and the Top-Board.

2.4. Conference Bus

We have to combine the components of management with the media application to construct the layered architecture. Conference bus can provide the service of conference components naming and the multicast based reliable (even the totally ordering) transmission. Based on those services, additional functions can be implemented, such as member management, floor control, the control of the media components and so on.

We can use the naming service of MBUS or CCCP conference bus in the hierarchy cooperation environment. The hierarchy information about the conference should be added to the naming space, which point out that whether it is a global conference component, a local component or an agent of the local conference, etc. We need to notice that conference bus advised presently does not prescribe the reliable multicast protocol in need. Especially there is no good approach to the issue of ordering in the large-scale multicast. We can rely on the reliable protocol, such as SRM or PGM, to achieve the reliable transmission. As to the question about the order, it aims at the fairness about the Floor Control. Even in the reliable multicast protocol, which has not implemented ordering scheme, we can adopt the policy of

chairmen-based floor control. In this way, the chairman can make the fair judgment on the base of history information about floor requests.

3. Related Work

At present there are two models to control the conference, loose coupling and tight coupling. Lightweight conferences lack explicit conference membership control and conference control mechanisms. Typically a lightweight session consists of a number of many-to-many multicast media streams. The only conference control information needed during the session is RTCP session information, i.e. an approximate membership list with some attributes per member. Tightly coupled conferences may also be multicast based and use RTP and RTCP, but in addition they have an explicit conference membership mechanism and may have an explicit conference control mechanism that provides facilities such as floor control.

The most widely used tightly coupled conference control protocols are ITU H.323 family [4]. However it should be noted that this is inappropriate for large-scale conferences caused by its conference control mechanisms. IETF gives the simple conference control protocol and the ITU presents H.332. They also want to address the scalability of the tight coupling conference.

It is difficult to construct a large-scale collaboration environment around the world if we have not any conference control mechanism. And it is not accurate and timely to complete the statistical task of lots of members. Our solution is to implement scalable control mechanism by using hierarchy method. In fact H.332 has the framework that tries to integrate the lightweight conference model and H.323. The difference between it and our blueprint is:

1) H.332 only divides the conference members into two parts: presidium and audience. Only when the audience enters the presidium, they can send the data stream. And it has not the concept of local conference group, which limits the interaction between the audience members outside the presidium.

2) H.332 uses the T.120 to transport the data (not video and audio). The protocol cannot communicate with the IP based reliable multicast protocol. It's a hard thing to extend all kinds of shared application on H.332. But many ideas of the control scheme in H.323 and H.332 are worthy of reference when we build the framework of hierarchy collaboration environment.

4. Conclusion

We propose a hierarchy collaborative environment structure, which divides the environment into area based two-level-structure. We use layered transmission technique combined with SSM for stream data, and use layered session scheme for whiteboard. Therefore we could control the network bandwidth usage and computing resource of each node, and improve the scalability of the whole collaborative environment.

The advantages of such layered collaborative environment are:

1) Hierarchy structure satisfies large-scale collaboration, especially for panel discussion scenario.

2) Adaptive with heterogeneity of Internet. It can dynamically allocate computing and communication resources according to the condition of network and collaboration scenarios.

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